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MANAGEMENT SYSTEMS FOR PERENNIAL BROADLEAVED WEEDS

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"Management Systems for Perennial Broadleaf Weeds"

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(a) Abstract / Summary:

A four-year project was initiated in the fall of 2005 on a farm field near Colonsay, SK that was heavily infested with dandelion (20 plants m^{-2}). The site location was SE 35 34 27 W2. Soil texture was a clay loam with a pH of 8.1 and soil Organic Matter content of 4.1%. The object was to evaluate the effectiveness of five herbicide programs designed for dandelion control that varied in herbicide intensity and timing in comparison to a No Perennial Weed Control (NPWC) check system that was designed to control only annual broadleaved weeds. A wheat – canola – barley – pea rotation was followed and all phases of the rotation were present each year resulting in a 24 treatment trial. Herbicide systems were evaluated by determining the numbers of established (>5 cm diameter) and seedling (<5 cm diameter) dandelions in the plots at three sampling dates each year (pre-seeding, just prior to in-crop herbicide application, and post-harvest). Grain yields were determined each year and the grain samples were graded by a grain company grain buyer. Gross returns from each system were calculated by applying the grain price for the crop and grade that was in effect for the 2008 / 2009 crop year. Net economic return from each system was determined by deducting the cost of all herbicide treatments and the herbicide application cost from the gross return. The following conclusions were reached:

- All five herbicide systems designed for dandelion control were superior to the NPWC check throughout each growing season.
- There were relatively few differences between systems that had an emphasis on fall treatment vs those that emphasized spring treatment. Our conclusion is that "doing something" to control dandelions is more important than the timing of the application.
- High intensity herbicide programs were more effective than Medium and Low Intensity systems for reducing dandelion numbers, especially numbers of established plants.The Fall Only High Intensity system appeared to be most effective for controlling established dandelion plants. In terms of overall weed control, the Spring Only High Intensity program was also quite effective. Although there were no significant differences in crop yield among the five systems designed to control dandelions, these two systems tended to result in the best yields and net economic returns. Thus we conclude that a relatively intensive herbicide program is required to maintain long-term control of an invasive species such as dandelion and maximize net returns.
- The Fall Start Low Intensity system which began with a heavy (900 g ai/ha) application of glyphosate and then reverted to a low intensity herbicide regime, provided initial control of established dandelions but it was not effective for controlling established dandelions over the four year course of the trial. It generally will require at least two

consecutive years of effective control to have a significant impact on a dandelion infestation.

- None of the herbicide systems were effective at preventing re-infestation of dandelion seedlings. Dandelion is a ubiquitous, wind dispersed species that can rapidly re-infest an area following effective control of the existing population. The conclusion is that a species such as dandelion will continuously reinvade an area in spite of effective control measures being applied.
- Established dandelions can reduce the yield of competitive crops, especially in years when spring moisture is limiting. In 2009 for example, yield increases of 38%, 20%, 14% and 50% were recorded in wheat, canola, barley and pea, respectively.
- Rating the overall performance of the systems in terms of weed control, crop yield and net economic return, the two most intensive herbicide systems, Fall Only High Intensity and Spring Only High Intensity appear to be the best choices.

(b) Introduction

Dandelion density is generally higher in reduced and zero-tillage systems than in conventional tillage (Legere and Sampson, 1999, Blackshaw et al., 1994, Arshad et al., 1994), and has been shown to be inversely proportional to tillage frequency (Chancellor, 1964). Dandelion infestations were also more severe in rotations that included a high frequency of poorly competitive broadleaf crops, such as peas, canola, flax, beans, and sunflowers (Stevenson and Johnson, 1999). Moreover, the deficiency of suitable in-crop herbicides for control of dandelions in broadleaf crops contributes to the high infestation levels (Froese and Van Acker, 2003). Leeson et al (2005) reported that dandelion moved from 22nd to 11th most abundant weed of field crops across the prairies from the 1970s (8.9% of fields, Relative Abundance = 3) to the 2000s (16.7% of fields, Relative Abundance = 6.9). This significant increase in the frequency and abundance of the weed coincided with the rapid adoption of direct-seeding technology in the prairies over the same time period. The increase in the abundance of this weed, especially in association with the increase direct-seeding practices triggered a desire to try to define the most cost-effective means of controlling the species in direct seeding systems.

The objective of this research was to develop best management practices for the management of dandelion in a cereal-oilseed-cereal-pulse rotation in western Canada. Best management practices will be examined on the basis of both weed control effectiveness and cost/benefit analysis.

(c) Methods:

This trial was initiated in the fall of 2005 on a farm field near Colonsay, SK that was heavily infested with dandelion (20 plants m^{-2}). The site location is SE 35 34 27 W2. Soil texture is clay loam with a pH of 8.1 and Organic Matter content of 4.1%.

Six weed management systems were evaluated within a four year rotation of wheat – canola – barley – pea. All phases of the rotation were present each year resulting in a 24 treatment trial. Treatments were replicated four times in a split-plot randomized complete block design where crops were the main plots and weed management systems were the sub-plots. The six weed management systems are described in Table 1. A summary description of the six herbicide systems is given in Table 1 and the full details of all cropping sequences, herbicides applied and the dates of their application are provided in Table 2. The No Perennial Weed Control system consisted of an annual pre-seed burnoff treatment with glyphosate at 450 g ai/ha followed by a recommended in-crop herbicide for annual weed control (Buctril M® in cereals, Odyssey® in peas and glyphosate in RR canola®). These treatments were expected to have minimal impact on the dandelion population and this system was included as the check (or "do nothing" system) against which the other systems were compared. The other five systems were designed to span a wide range of herbicide intensity (low, medium, high) using products with known activity on dandelion applied at various times of the year. The general lay-out of the field trial is shown in Figure 1. Unless otherwise specified, herbicides were applied at recommended rates.

Table 1. Description of six weed management systems evaluated for control of dandelion near, Colonsay, SK, 2005 – 2009

No Perennial Weed Control (NPWC). Annual Weed Control Only (The "Control or Check" System).	Standard glyphosate burn-off in spring, Buctril M on cereals, glyphosate on RR canola and Odyssey on pea.
Fall Only, High Intensity	Receives a fall treatment every year. PrePass burn-off prior to cereal crops, glyphosate at 900 g ai/ha prior to canola and peas. Standard glyphosate burn-off each spring and same in-crop treatments as NPWC above.
Fall Start, Low Intensity	Glyphosate at 900 g ai/ha in fall prior to yr 1. No further fall treatments. Standard glyphosate burn-off each spring (glyphosate + carfentrazone in 2009). Frontline or Buctril M on cereals, glyphosate on RR canola and Odyssey on peas.
Fall Start, Medium Intensity	PrePass in the first fall prior to wheat and barley, glyphosate at 900 g ai/ha prior to canola and peas and no fall treatment for the next two years. Standard burn-off with glyphosate each spring. Spectrum / Frontline in wheat & barley, Eclipse in canola, Odyssey in peas.
Spring Only, High Intensity	PrePass prior to each cereal crop, high rate glyphosate (900 g ai/ha) prior to canola and peas each spring. Same in-crop treatments as NPWC above.
Spring Start, Medium Intensity	Glyphosate burn-off each spring, 900 g ai/ha in yr 1 and 450 g ai/ha each year thereafter. 2, 4-D or glyphosate in the fall of years 2 & 3 (2,4-D before cereals and glyphosate before canola or peas). Frontline or Buctril M on cereals, Odyssey on peas and glyphosate on RR canola.

Plots (4 x 12 m) were established and harvested with standard small plot equipment belonging to the Department of Plant Sciences / Crop Development Centre.

Seeding - plots were seeded with a *Rogers Innovations* no-till drill equipped with nine Harmon single shoot Eagle point hoe openers spaced 20 cm apart. Seeding depth was appropriate for each crop and moisture conditions at the time. The crop varieties used and their seeding rates are given in Table 2.

Spraying - treatments were applied with 110015 ABJ venture nozzles set at 46 cm above the target. The sprayer was a three-point hitch tractor mounted sprayer with an eight m wide boom. It delivered 100 L/ha of spray solution when operated at a speed of 7.6 km/hour and at a nozzle pressure of 275 kPa.

Harvest - plots were harvested using a *Hege* 140 small plot combine with a 1.2 M header and adjustable sieves. Samples were dried on a forced air (30 °C) box dryer for an average of 48 hrs. and cleaned before weighing.

Weed Control / Crop Injury Assessment – weed control and crop injury are rated visually on 2 or 3 dates. Assessments are reported using the visual rating scale approved by the Canadian

Weed Science Society. In that system a rating of 80% control is considered to be the minimum acceptable whereas a rating of 10% is the maximum acceptable level of crop injury.

Dandelion Plant Counts – dandelions were counted at three times during each growing season: pre-seeding, at time of in-crop herbicide application and post-harvest. Counts were made in four quadrats in each plot, each quadrat being 0.5 m^2. The plants were classified as seedlings (<5 cm diameter) or established plants (> 5 cm diameter).

Crop Grading – Each year a grain sample from each treatment was submitted to Viterra for grade determination to see if management system had any effect on the grade of the crop. For wheat, the protein concentration was also determined and barley was consider malting quality if the sample was >85% plump kernels. Grade information was also used to determine what price to assign to the crop when calculating the net return for each weed management system.

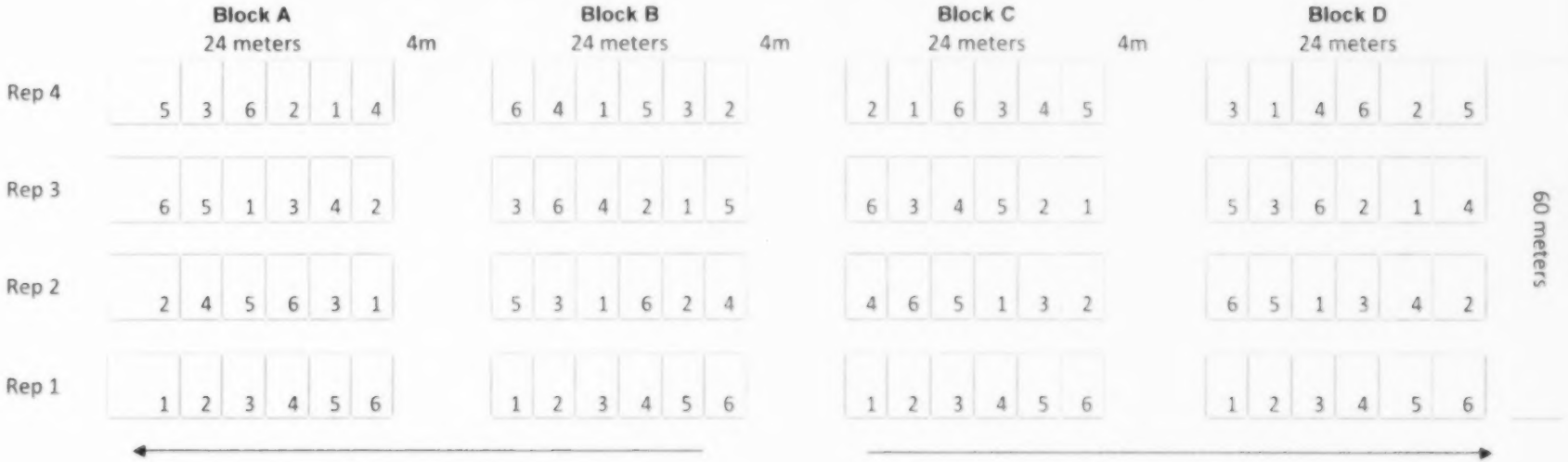
Statistical Analysis - Dandelion density and control data were analyzed separately for each year with the PROC GLIMMIX procedure of SAS (SAS Institute 2005). The effect of replicate was considered random and the effect of the applied treatments was considered fixed. A negative binomial probability distribution and log link function model specifications was used for these analyses.

Yield data also were analyzed with the PROC GLIMMIX procedure of SAS (SAS Institute 2005). The effects of replicate and year were considered random, and the effect of the applied treatments was considered fixed. In addition to year as a random effect, the effect of year also was considered to be a time-related continuous variable completely cross-classified with the applied treatments for data from the long-term rotations. This model configuration allowed for an assessment of random variation of treatment effects across years and linear deviations for treatment effects over time. Measurements were repeated on the same experimental unit (plot) across years. A first-order autoregressive covariance structure (correlation between year's decreases as the number of years between measurements increases) was used to model the repeated measurements.

Treatment effects were declared significant at $P < 0.05$.

Economic Analysis – The cost of the herbicides used in each management system was derived from the 2009 and 2010 versions of the Guide to Crop Protection published by the Saskatchewan Ministry of Agriculture. These are suggested retail prices and so are slightly higher than actual costs because they do not take volume discounts and other special pricing programs into account. The cost of herbicide application was set at $4.00/acre for each application. Wheat and barley prices used in the analysis were the final prices for the 2008 / 2009 crop year as listed on the Canadian Wheat Board website based on specific grades and protein concentration. Prices for canola ($8.75/bu) and peas ($5.75/bu for LYP 1, $5.00/bu for LYP 2 and $4.00/bu for LYP 3) were obtained from Viterra and were used a s representative for these crops. The net return for each crop in each management system was calculated by multiplying the yield x the price and subtracting the total cost of herbicide used in the system plus the cost of herbicide application.

Figure 1. Field plot layout for the dandelion control experiment near Colonsay, SK. 2005 - 2009.



Block A Rotation		Block B Rotation		Block C Rotation		Block D Rotation	
2005	Wheat	2005	Wheat	2005	Wheat	2005	Wheat
2006	Wheat	2006	RR Canola	2006	Barley	2006	Peas
2007	RR Canola	2007	Barley	2007	Peas	2007	Wheat
2008	Barley	2008	Peas	2008	Wheat	2008	RR Canola
2009	Peas	2009	Wheat	2009	RR Canola	2009	Barley

Table 2. Herbicide applications and crop establishment parameters for the dandelion control field experiment near Colonsay, SK. 2005-2009.

Perbi Dandelion Colonsay Block A - Wheat Start (Rotation = Wheat – Canola – Barley – Pea)

Herbicide System	Year	Crop	Seed Date	Pre-Seed Burnoff	Preseed Burnoff App Date	In-Crop Treatment	Post-E Application Date	Post-Harvest Treatment	Post-harvest App Date
No Perennial Weed Control (Check Treatment)	First Fall-05	stubble							
	A-2006	Wheat	19-May-06	Glyphosate 450 gai/ha	15-May-06	Buctril M	16-Jun-06		
	B-2007	Canola (RR)	18-May-07	Glyphosate 450 gai/ha	16-May-07	Glyphosate 450 gai	14-Jun-07		
	C-2008	Barley	29-May-08	Glyphosate 450 gai/ha	27-May-08	Buctril M	23-Jun-08		
	D-2009	Peas	27-May-09	Glyphosate 450 gai/ha	23-May-09	Odyssey	26-Jun-09		
Fall Only High Intensity	First Fall-05	stubble						Prepass	12-Oct-05
	A-2006	Wheat	19-May-06	Glyphosate 300 gai/ha	15-May-06	Buctril M	16-Jun-06	Glyphosate 900 gai/ha	2-Oct-06
	B-2007	Canola (RR)	18-May-07	Glyphosate 450 gai/ha	16-May-07	Glyphosate 450 gai	14-Jun-07	PrePass	27-Sep-07
	C-2008	Barley	29-May-08	Glyphosate 300 gai/ha	27-May-08	Buctril M	23-Jun-08	Glyphosate 900 gai/ha	25-Sep-08
	D-2009	Peas	27-May-09	Glyphosate 450 gai/ha	23-May-09	Odyssey	26-Jun-09		
Spring Only High Intensity	First Fall-05	stubble							
	A-2006	Wheat	19-May-06	PrePass	15-May-06	Buctril M	16-Jun-06		
	B-2007	Canola (RR)	18-May-07	Glyphosate 900 gai/ha	16-May-07	Glyphosate 450 gai	14-Jun-07		
	C-2008	Barley	29-May-08	PrePass	27-May-08	Buctril M	23-Jun-08		
	D-2009	Peas	27-May-09	Glyphosate 900 gai/ha	23-May-09	Odyssey	26-Jun-09		
Fall Start Medium Intensity	First Fall-05	stubble						PrePass	12-Oct-05
	A-2006	Wheat	19-May-06	Glyphosate 300 gai/ha	15-May-06	Spectrum	16-Jun-06		
	B-2007	Canola (RR)	18-May-07	Glyphosate 450 gai/ha	16-May-07	Eclipse	14-Jun-07		
	C-2008	Barley	29-May-08	Glyphosate 450 gai/ha	27-May-08	Frontline	23-Jun-08	Glyphosate 900 gai	25-Sep-08
	D-2009	Peas	27-May-09	Glyphosate 450 gai/ha	23-May-09	Odyssey	26-Jun-09		

Spring Start Medium Intensity	First Fall-05	stubble							
	A-2006	Wheat	19-May-06	Glyphosate 900 gai/ha	15-May-06	Frontline	16-Jun-06		
	B-2007	Canola (RR)	18-May-07	Glyphosate 450 gai/ha	16-May-07	Glyphosate 450 gai	14-Jun-07	2,4-D 560 Ester	27-Sep-07
	C-2008	Barley	29-May-08	Glyphosate 450 gai/ha	27-May-08	Buctril M	23-Jun-08	Glyphosate 450 gai/ha	25-Sep-08
	D-2009	Peas	27-May-09	Glyphosate 450 gai/ha	23-May-09	Odyssey	26-Jun-09		
Fall Start Low Intensity	First Fall-05	stubble						Glyphosate 900 gai/ha	12-Oct-05
	A-2006	Wheat	19-May-06	Glyphosate 450 gai/ha	15-May-06	Frontline 2,4-D	16-Jun-06		
	B-2007	Canola (RR)	18-May-07	Glyphosate 450 gai/ha	16-May-07	Glyphosate 450 gai	14-Jun-07		
	C-2008	Barley	29-May-08	Glyphosate 450 gai/ha	27-May-08	Buctril M	23-Jun-08		
	D-2009	Peas	27-May-09	Glyphosate 450 gai/ha	23-May-09	Odyssey	26-Jun-09		

Year	Crop	Variety	Seeding Rate kg/ha	Seed Placed 11-52-0 kg/ha (prod)	N Fertilization Kg N/ha	N app date	
2006	Wheat	Eatonia	85	54	56	7-Jun-06	
2007	Canola	9525	7	33	55	5-Jun-07	swathed Aug 9 /07
2008	Barley	AC Metcalfe	75	54	55	3-Jun-08	
2009	Pea	CDC Mozart	185	33	0		

Perbi Dandelion Colonsay Block B - Canola Start (Rotation = Canola – Barley – Pea – Wheat)

Herbicide System	Year	Crop	Seed Date	Pre-Seed Burnoff Treatment	Preseed Burnoff Appl Date	In-Crop Treatment	Post-E App Date	Post-Harvest Treatment	Post-harvest App Date
	First Fall-05	stubble							
No Perennial Weed Control (Check Treatment)	A-2006	Canola (RR)	19-May-06	Glyphosate 450 gai/ha	15-May-06	Glyphosate 450 gai	16-Jun-06		
	B-2007	Barley	18-May-07	Glyphosate 450 gai/ha	16-May-07	Buctril M	20-Jun-07		
	C-2008	Peas	29-May-08	Glyphosate 450 gai/ha	27-May-08	Odyssey	23-Jun-08		
	D-2009	Wheat	27-May-09	Glyphosate 450 gai/ha	23-May-09	Buctril M	26-Jun-09		
Fall Only High Intensity	First Fall-05	stubble						Glyphosate 900 gai/ha	12-Oct-05
	A-2006	Canola (RR)	19-May-06	Glyphosate 450 gai/ha	15-May-06	Glyphosate 450 gai	16-Jun-06	PrePass	2-Oct-06
	B-2007	Barley	18-May-07	Glyphosate 300 gai/ha	16-May-07	Buctril M	20-Jun-07	Glyphosate 900 gai	27-Sep-07
	C-2008	Peas	29-May-08	Glyphosate 450 gai/ha	27-May-08	Odyssey	23-Jun-08	Prepass	25-Sep-08
	D-2009	Wheat	27-May-09	Glyphosate 300 gai/ha	23-May-09	Buctril M	26-Jun-09		
Spring Only High Intensity	First Fall-05	stubble							
	A-2006	Canola (RR)	19-May-06	Glyphosate 900 gai/ha	15-May-06	Glyphosate 450 gai	16-Jun-06		
	B-2007	Barley	18-May-07	PrePass	16-May-07	Buctril M	20-Jun-07		
	C-2008	Peas	29-May-08	Glyphosate 900 gai/ha	27-May-08	Odyssey	23-Jun-08		
	D-2009	Wheat	27-May-09	PrePass	23-May-09	Buctril M	26-Jun-09		
Fall Start Medium Intensity	First Fall-05	stubble						Glyphosate 900 gai/ha	12-Oct-05
	A-2006	Canola (RR)	19-May-06	Glyphosate 450 gai/ha	15-May-06	Eclipse	16-Jun-06		
	B-2007	Barley	18-May-07	Glyphosate 450 gai/ha	16-May-07	Spectrum	20-Jun-07		
	C-2008	Peas	29-May-08	Glyphosate 450 gai/ha	27-May-08	Odyssey	23-Jun-08	PrePass	25-Sep-08
	D-2009	Wheat	27-May-09	Glyphosate 300 gai/ha	23-May-09	Frontline 2,4-D	26-Jun-09		

Spring Start Medium Intensity	First Fall-05	stubble							
	A-2006	Canola (RR)	19-May-06	Glyphosate 900 gai/ha	15-May-06	Glyphosate 450 gai	16-Jun-06		
	B-2007	Barley	18-May-07	Glyphosate 450 gai/ha	16-May-07	Frontline	20-Jun-07	Glyphosate 450 gai/ha	27-Sep-07
	C-2008	Peas	29-May-08	Glyphosate 450 gai/ha	27-May-08	Odyssey	23-Jun-08	2,4-D 560 Ester	25-Sep-08
	D-2009	Wheat	27-May-09	Glyphosate 450 gai/ha	23-May-09	Buctril M	26-Jun-09		
Fall Start Low Intensity	First Fall-05	stubble						Glyphosate 900 gai/ha	12-Oct-05
	A-2006	Canola (RR)	19-May-06	Glyphosate 450 gai/ha	15-May-06	Glyphosate 450 gai	16-Jun-06		
	B-2007	Barley	18-May-07	Glyphosate 450 gai/ha	16-May-07	Frontline	20-Jun-07		
	C-2008	Peas	29-May-08	Glyphosate 900 gai/ha	27-May-08	Odyssey	23-Jun-08		
	D-2009	Wheat	27-May-09	Glyphosate 450 gai/ha	23-May-09	Buctril M	26-Jun-09		

Year	Crop	Variety	Seeding Rate kg/ha	Seed Placed 11-52-0 kg/ha (prod)	N Fertilization Kg N/ha	N app date	
2006	Canola	9525	7	33	56	7-Jun-06	Canola plots swathed Aug 10/06
2007	Barley	AC Metcalfe	75	54	55	5-Jun-07	
2008	Pea	CDC Mozart	185	35	22	3-Jun-08	
2009	Wheat	Eatonia	89	54	60	9-Jun-09	Oversprayed with Axial .6L/ha June 28/09

Perbi Dandelion Colonsay Block C - Barley Start (Rotation = Barley – Pea – Wheat – Canola)

Herbicide System	Year	Crop	Seed Date	Pre-Seed Burnoff	Preseed Application Date	In-Crop Treatment	Post-E Application Date	Post-Harvest Treatment	Post-harvest Date
No Perennial Weed Control (Check Treatment)	First Fall-05	stubble							
	A-2006	Barley	19-May-06	Glyphosate 450 gai/ha	15-May-06	Buctril M	16-Jun-06		
	B-2007	Peas	18-May-07	Glyphosate 450 gai/ha	16-May-07	Odyssey	14-Jun-07		
	C-2008	Wheat	29-May-08	Glyphosate 450 gai/ha	27-May-08	Buctril M	23-Jun-08		
	D-2009	Canola (RR)	27-May-09	Glyphosate 450 gai/ha	23-May-09	Glyphosate 450 gai	28-Jun-09		
Fall Only High Intensity	First Fall-05	stubble						Prepass	12-Oct-05
	A-2006	Barley	19-May-06	Glyphosate 300 gai/ha	15-May-06	Buctril M	16-Jun-06	Glyphosate 900 gai/ha	2-Oct-06
	B-2007	Peas	18-May-07	Glyphosate 450 gai/ha	16-May-07	Odyssey	14-Jun-07	PrePass	27-Sep-07
	C-2008	Wheat	29-May-08	Glyphosate 300 gai/ha	27-May-08	Buctril M	23-Jun-08	Glyphosate 900 gai/ha	25-Sep-08
	D-2009	Canola (RR)	27-May-09	Glyphosate 450 gai/ha	23-May-09	Glyphosate 450 gai	28-Jun-09		
Spring Only High Intensity	First Fall-05	stubble							
	A-2006	Barley	19-May-06	PrePass	15-May-06	Buctril M	16-Jun-06		
	B-2007	Peas	18-May-07	Glyphosate 900 gai/ha	16-May-07	Odyssey	14-Jun-07		
	C-2008	Wheat	29-May-08	PrePass	27-May-08	Buctril M	23-Jun-08		
	D-2009	Canola (RR)	27-May-09	Glyphosate 900 gai/ha	23-May-09	Glyphosate 450 gai	28-Jun-09		
Fall Start Medium Intensity	First Fall-05	stubble						PrePass	12-Oct-05
	A-2006	Barley	19-May-06	Glyphosate 300 gai/ha	15-May-06	Spectrum	16-Jun-06		
	B-2007	Peas	18-May-07	Glyphosate 450 gai/ha	16-May-07	Odyssey	14-Jun-07		
	C-2008	Wheat	29-May-08	Glyphosate 450 gai/ha	27-May-08	Frontline	23-Jun-08	Glyphosate 900 gai/ha	25-Sep-08
	D-2009	Canola (RR)	27-May-09	Glyphosate 450 gai/ha	23-May-09	Eclipse	28-Jun-09		

Spring Start Medium Intensity	First Fall-05	stubble							
	A-2006	Barley	19-May-06	Glyphosate 900 gai/ha	15-May-06	Frontline	16-Jun-06		
	B-2007	Peas	18-May-07	Glyphosate 450 gai/ha	16-May-07	Odyssey	14-Jun-07	2,4-D 560 Ester	27-Sep-07
	C-2008	Wheat	29-May-08	Glyphosate 450 gai/ha	27-May-08	Buctril M	23-Jun-08	Glyphosate 450 gai/ha	25-Sep-08
	D-2009	Canola (RR)	27-May-09	Glyphosate 450 gai/ha	23-May-09	Glyphosate 450 gai	28-Jun-09		
Fall Start Low Intensity	First Fall-05	stubble						Glyphosate 900 gai/ha	12-Oct-05
	A-2006	Barley	19-May-06	Glyphosate 450 gai/ha	15-May-06	Frontline 2,4-D	16-Jun-06		
	B-2007	Peas	18-May-07	Glyphosate 450 gai/ha	16-May-07	Odyssey	14-Jun-07		
	C-2008	Wheat	29-May-08	Glyphosate 450 gai/ha	27-May-08	Buctril M	23-Jun-08		
	D-2009	Canola (RR)	27-May-09	Glyphosate 450 gai/ha	23-May-09	Glyphosate 450 gai	28-Jun-09		

Barley desiccated with Reglone Aug 10/06

Year	Crop	Variety	Seeding Rate kg/ha	Seed Placed 11-52-0 kg/ha (prod)	N Fertilization Kg N/ha	N app date
2006	Barley	Metcalfe	90	54	56	7-Jun-06
2007	Pea	CDC Mozart	185	35	0	NA
2008	Wheat	AC Eatonia	84	54	55	3-Jun-08
2009	Canola	9525	7	33	67	9-Jun-09

Perbi Dandelion Colonsay Block D - Pea Start (Rotation = Pea – Wheat – Canola – Barley)

Herbicide System	Year	Crop	Seed Date	Pre-Seed	Preseed Application Date	In-Crop Treatment	Post-E Application Date	Post-Harvest Treatment	Post-harvest Date
	First Fall-05	stubble							
No Perennial Weed Control (Check Treatment)	A-2006	Peas	19-May-06	Glyphosate 450 gai/ha	15-May-06	Odyssey	16-Jun-06		
	B-2007	Wheat	18-May-07	Glyphosate 450 gai/ha	16-May-07	Buctril M	20-Jun-07		
	C-2008	Canola (RR)	29-May-08	Glyphosate 450 gai/ha	27-May-08	Glyphosate 450 gai/ha	23-Jun-08		
	D-2009	Barley	27-May-09	Gly 450 + Aim 8.7 gai/ha	23-May-09	Buctril M	28-Jun-09		
Fall Only High Intensity	First Fall-05	stubble							
	A-2006	Peas	19-May-06	Glyphosate 450 gai/ha	15-May-06	Odyssey	16-Jun-06	Glyphosate 900 gai/ha	12-Oct-05
	B-2007	Wheat	18-May-07	Glyphosate 300 gai/ha	16-May-07	Frontline 2,4-D	20-Jun-07	PrePass	2-Oct-06
	C-2008	Canola (RR)	29-May-08	Glyphosate 450 gai/ha	27-May-08	Glyphosate 450 gai/ha	23-Jun-08	Glyphosate 900 gai/ha	27-Sep-07
	D-2009	Barley	27-May-09	Gly 300 + Aim 8.7 gai/ha	23-May-09	Frontline	28-Jun-09	Prepass	25-Sep-08
Spring Only High Intensity	First Fall-05	stubble							
	A-2006	Peas	19-May-06	Glyphosate 900 gai/ha	15-May-06	Odyssey	16-Jun-06		
	B-2007	Wheat	18-May-07	PrePass	16-May-07	Buctril M	20-Jun-07		
	C-2008	Canola (RR)	29-May-08	Glyphosate 900 gai/ha	27-May-08	Glyphosate 450 gai/ha	23-Jun-08		
	D-2009	Barley	27-May-09	PrePass	23-May-09	Buctril M	28-Jun-09		
Fall Start Medium Intensity	First Fall-05	stubble							
	A-2006	Peas	19-May-06	Glyphosate 450 gai/ha	15-May-06	Odyssey	16-Jun-06	Glyphosate 900 gai/ha	12-Oct-05
	B-2007	Wheat	18-May-07	Glyphosate 450 gai/ha	16-May-07	Spectrum	20-Jun-07	2,4-D 560 Ester	2-Oct-06
	C-2008	Canola (RR)	29-May-08	Glyphosate 450 gai/ha	27-May-08	Eclipse	23-Jun-08	PrePass	25-Sep-08
	D-2009	Barley	27-May-09	Gly 300 + Aim 8.7 gai/ha	23-May-09	Frontline	28-Jun-09		
Spring	First Fall-05	stubble							
	A-2006	Peas	19-May-06	Glyphosate 900 gai/ha	15-May-06	Odyssey	16-Jun-06		

Start Medium Intensity	B-2007	Wheat	18-May-07	Glyphosate 450 gai/ha	16-May-07	Frontline 2,4-D	20-Jun-07	Glyphosate 450 gai/ha	27-Sep-07
	C-2008	Canola (RR)	29-May-08	Glyphosate 450 gai/ha	27-May-08	Glyphosate 450 gai/ha	23-Jun-08	2,4-D 560	25-Sep-08
	D-2009	Barley	27-May-09	Gly 450 + Aim 8.7 gai/ha	23-May-09	Buctril M	28-Jun-09		
Fall Start Low Intensity	First Fall-05	stubble						Glyphosate 900 gai /ha	12-Oct-05
	A-2006	Peas	19-May-06	Glyphosate 450 gai/ha	15-May-06	Odyssey	16-Jun-06		
	B-2007	Wheat	18-May-07	Glyphosate 450 gai/ha	16-May-07	Frontline 2,4-D	20-Jun-07		
	C-2008	Canola (RR)	29-May-08	Glyphosate 450 gai/ha	27-May-08	Glyphosate 450 gai/ha	23-Jun-08		
	D-2009	Barley	27-May-09	Gly 450 + Aim 8.7 gai/ha	23-May-09	Buctril M	28-Jun-09		

Pea Dessicated with Reglone Aug10/06

Year	Crop	Variety	Seeding Rate kg/ha	Seed Placed 11-52-0 kg/ha (prod)	N Fertilization Kg N/ha	N app date	
2006	Pea	Mozart	185	33	56	7-Jun-06	
2007	Wheat	AC Eatonia	84	54	55	5-Jun-07	
2008	Canola	9525	7	35	55	27-May-08	
2009	Barley	AC Metcalfe	75	54	67	9-Jun-09	Oversprayed with Axial .6L/ha June 28/09

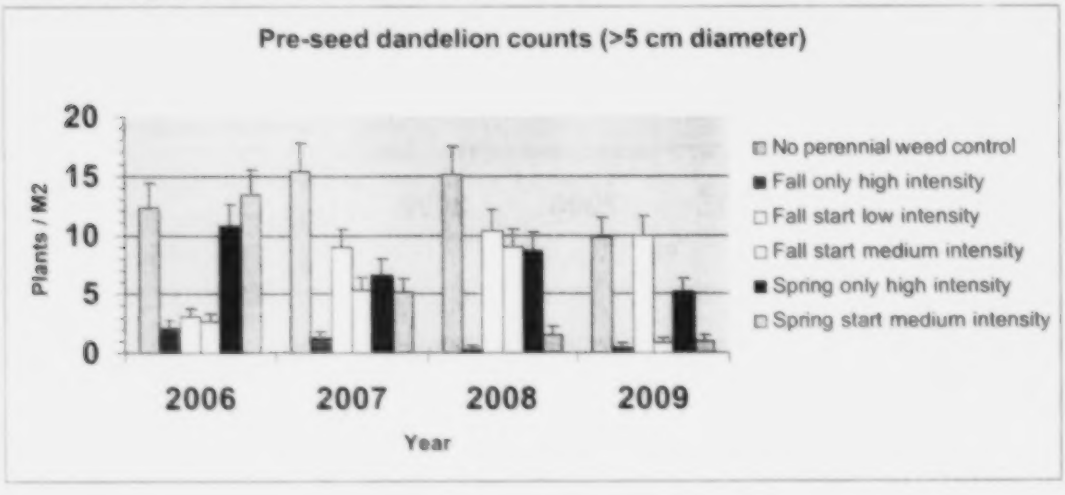
(d) Results

Dandelion Numbers Prior to Seeding.

The population of established dandelions (>5 cm diameter) in the No Perennial Weed Control (NPWC) check did not change substantially over the course of the experiment (Figure 2). In the spring of 2006, there were approximately 12 plants m^{-2} in this treatment and 3 years later there were approximately 10 plants m^{-2}. In the intervening years, there was about 15 established dandelions m^{-2} in these plots. Three perennial weed control systems had an immediate impact on the number of established dandelions namely, Fall Only High Intensity, Fall Start Medium Intensity and Fall Start Low Intensity. This is not surprising as all three of these systems received a treatment in the fall of 2005 whereas the other systems were not initiated until the spring of 2006. The one system that stands out as providing consistently good control of established dandelions is the Fall Only, High Intensity system. Dandelion numbers were reduced to about four m^{-2} in 2006 and declined further throughout the trial, ending up at a density of about 1 plant m^{-2} in the spring of 2009. The Spring Only High Intensity system was not effective in 2006 but control improved somewhat in subsequent years, averaging about 50% in 2007, 2008 and 2009. The Fall Start Medium Intensity system provided good initial control of dandelions but numbers increased in 2007 and 2008. Another fall treatment in this system in 2008 resulted in excellent control of dandelions by the spring of 2009. The Spring Start Medium Intensity system was ineffective in 2006 (as expected) but dandelion numbers declined significantly in 2007 and by 2008 this system was providing excellent control as was the case in 2009. The Fall Start Low Intensity system controlled established dandelions initially but failed to maintain control thereafter. By 2009, the dandelion numbers in this system were the same as in the NPWC check.

For established dandelions, the contrast comparing application of herbicides for perennial weed control vs the NPWC system was highly significant in 2006, 2007 and 2008 as was the contrast for differences among the treatments in 2008 and 2009. In 2007, this contrast was significant. The contrast comparing High Intensity vs Medium / Low Intensity herbicide application was highly significant in 2007 and 2008 but not in 2009. The contrast for comparison of Spring vs Fall based systems was not significant in any of the three years.

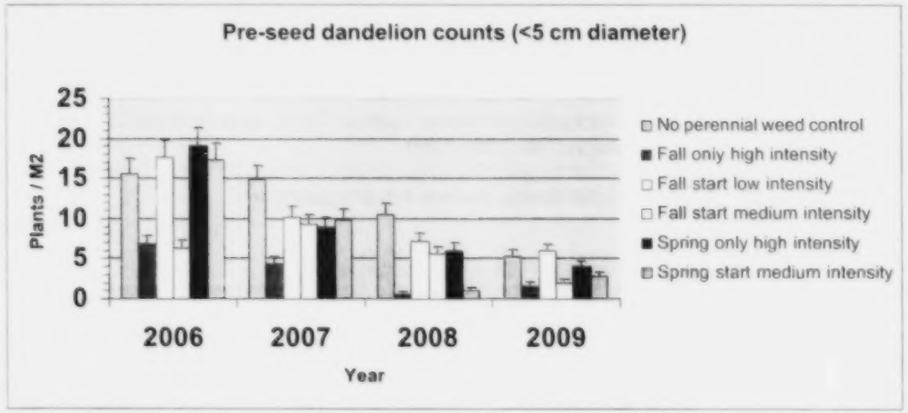
Figure 2. Effect of herbicide intensity on the numbers of established dandelion plants present prior to crop seeding averaged over wheat, canola, barley and field pea crops in a direct seeding system near Colonsay, SK, 2006-2009.



Early spring (pre-seeding) seedling dandelion numbers declined over the course of the experiment, likely due to the cool, dry weather experienced in the springs of 2008 and 2009 (Figure 3). In the spring of 2006, seedling dandelion numbers were reduced only by the Fall Only High and Medium Intensity systems. Both of these systems included an application of glyphosate + florasulam (PrePass®) in the fall of 2005 which would have controlled existing seedlings and provided residual control of early spring germinating seedlings. In 2007, spring seedling numbers were reduced by all five of the systems designed to provide dandelion control but the Fall Only High Intensity system was better than the other four systems which did not differ among themselves. All five dandelion management systems reduced dandelion seedling numbers in the spring of 2008 as well. In this case, both the Fall Only High Intensity and the Spring Start Medium Intensity systems were superior to the other three systems. The latter system provided progressively better seedling control from 2006 to 2007 to 2008. Early spring seedling numbers were relatively low in 2009 and were reduced by all the dandelion control systems except for the Fall Start Low Intensity system when compared to the NPWC system which was similar to the check treatment. The Spring Only High Intensity system also did not provide effective control of seedlings prior to seeding.

For seedling dandelions, the contrast comparing application of herbicides for perennial weed control vs the NPWC system was highly significant in 2006, 2007 and 2008 as was the contrast for differences among the treatments. The contrast comparing High Intensity vs Medium / Low Intensity herbicide application was highly significant in 2007, significant in 2008 but not significant in 2009. The contrast for comparison of Spring vs Fall based systems was not significant in any of the three years.

Figure 3. Effect of herbicide intensity on the numbers of seedling dandelion plants present prior to crop seeding averaged over wheat, canola, barley and field pea crops in a direct seeding system near Colonsay, SK, 2006-2009.



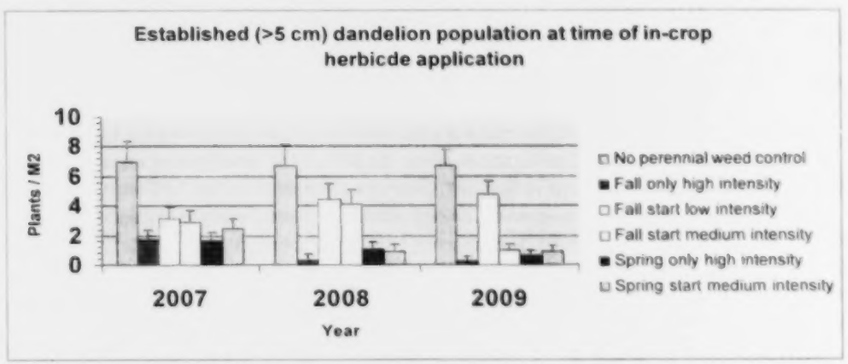
Dandelion numbers at time of in-crop herbicide application.

The number of established dandelions at the time of in-crop herbicide applications was determined in 2007, 2008 and 2009. The NPWC check treatment had no effect on dandelion numbers at this time of year as there were approximately seven established plants m^{-2} in all three years (Figure 4). All of the other five herbicide systems reduced the dandelion population to 2 to

3 plants m^{-2} and the differences between these systems were slight. The Fall Only High Intensity and the Spring Only High Intensity systems appeared to have the greatest impact on established dandelions. In 2008, the Fall Only High Intensity, the Spring Only High Intensity and the Spring Start medium Intensity systems provided excellent control of established dandelions whereas the Fall Start Low and Medium Intensity systems provided only a slight reduction in dandelion numbers. By 2009, dandelion control at this time of year was excellent except for the Fall Start Low Intensity system which was only slightly better than the NPWC check treatment

For established dandelions, the contrast comparing application of herbicides for perennial weed control vs the NPWC system was highly significant in 2006, 2007 and 2008 as was the contrast for differences among the treatments in 2008 and 2009. In 2007, this contrast was not significant. The contrast comparing High Intensity vs Medium / Low Intensity herbicide application was highly significant in 2008 and 2009 and significant in 2007. The contrast for comparison of Spring vs Fall based systems was significant only in 2008.

Figure 4. Effect of herbicide intensity on the numbers of established dandelion plants present at time of in-crop herbicide application averaged over wheat, canola, barley and field pea crops in a direct seeding system near Colonsay, SK, 2007-2009.

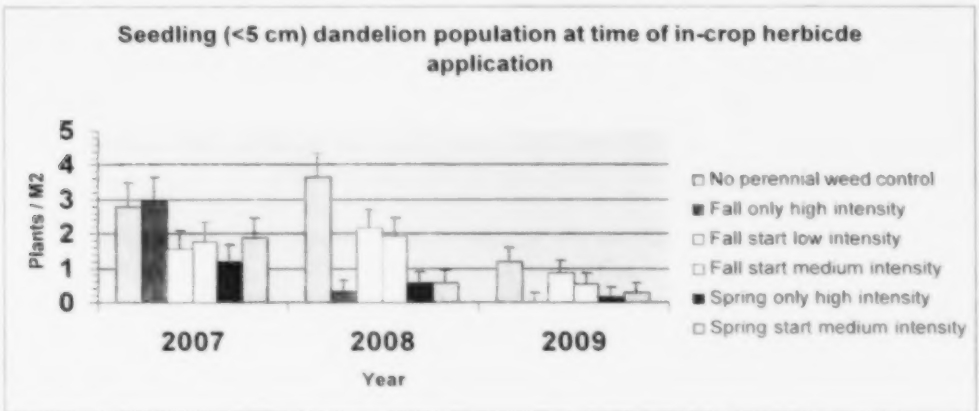


The number of seedling dandelions present at the time of in-crop herbicide treatment was relatively low and was affected by the herbicide treatments in all three years (Figure 5). However the relative effectiveness of the herbicide systems changed somewhat over time. In 2007, the Fall Only High Intensity System had no impact on seedling numbers whereas the other four systems all reduced seedling numbers by about 50%. In 2008, the Fall Start Low and Fall Start Medium Intensity systems were the weakest systems, providing only about 50% reduction in seedling numbers. The other three systems reduced seedling numbers by about 85%. Overall seedling numbers were very low in 2009 and, again, the Fall Start Low Intensity system was the weakest. There were no dandelion seedlings detected in the Fall Only High Intensity system.

The number of seedling dandelion present at the time of in-crop herbicide application in response to treatment with herbicides for perennial weed control vs the NPWC check was not as consistent as was the response of established plants. The contrast for herbicides for perennial weed control vs the NPWC system was not significant in 2007, highly significant in 2008 and significant in 2009. The contrast for differences among the treatments was highly significant in 2008 but not

significant in 2007 and 2009 as was the contrast for High Intensity vs Medium / Low herbicide Intensity. The contrast for comparison of Spring vs Fall based systems was significant only in 2008.

Figure 5. Effect of herbicide intensity on the numbers of seedling dandelion plants present at time of in-crop herbicide application averaged over wheat, canola, barley and field pea crops in a direct seeding system near Colonsay, SK, 2007-2009.

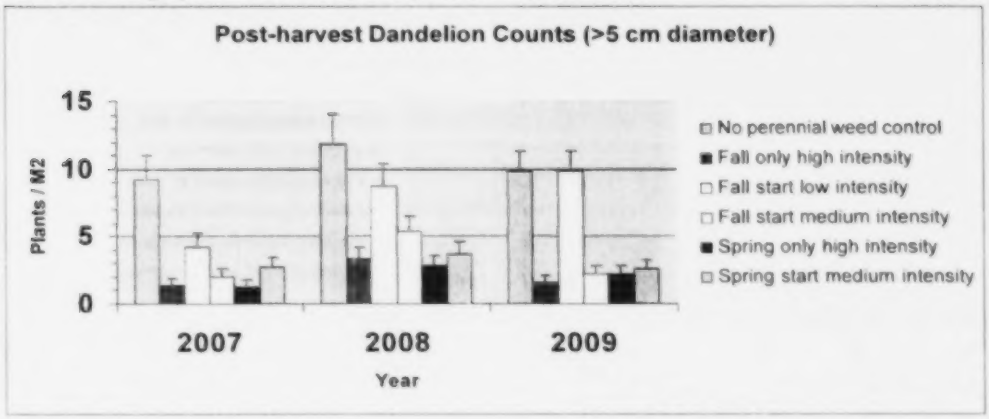


Dandelion Numbers Post-harvest.

The impact of the herbicide systems on the number of established dandelions present in the plots following crop harvest is summarized in Figure 6. The NPWC check had little or no impact on the number of established plants present in the fall. With the exception of the Fall Start Low Intensity system, the other systems designed to control perennial weeds were fairly successful and the differences in dandelion numbers were usually not significant. The Fall Start Low Intensity system initially reduced the population of established dandelions by nearly 50% but by the fall of 2008, the dandelion population in this system had rebounded and was similar to that in the NPWC system. In the fall of 2009, the dandelion numbers in these two systems were identical. These results show that a low intensity herbicide program is not effective for reducing the numbers of established dandelions on an on-going basis. Medium and high intensity herbicide systems were both effective at reducing the dandelion population to a low level when initiated in either the fall or the spring.

The contrasts for established dandelion numbers in response to herbicide treatments was quite consistent for plant counts made after harvest. The contrast for herbicide treatment vs the NPWC system was highly significant in all three years as were the contrasts for herbicide treatment and for the comparison of High Intensity vs Medium / Low herbicide intensity. The contrast for comparison of Spring vs Fall based systems was significant only in 2008.

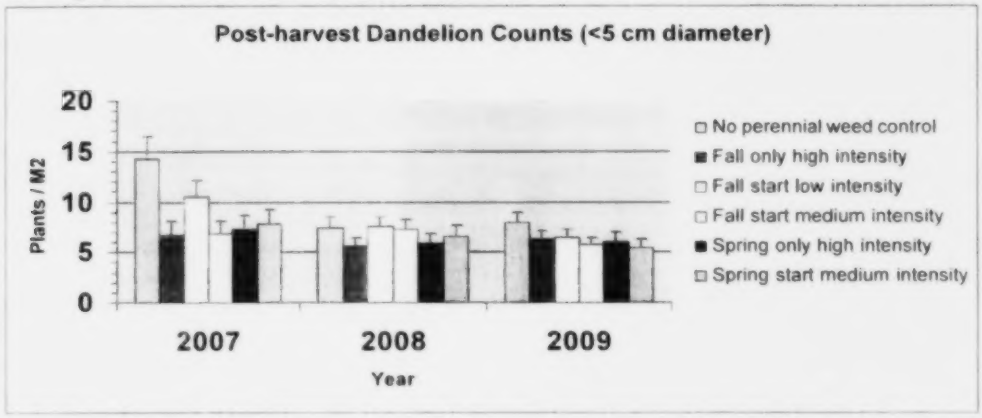
Figure 6. Effect of herbicide intensity on the numbers of established dandelion plants present after crop harvest averaged over wheat, canola, barley and field pea crops in a direct seeding system near Colonsay, SK, 2006-2009.



Herbicide systems had a less dramatic and more uniform impact on the number of seedling dandelions present in the plots in the fall. In 2007, the five systems designed for perennial weed control had reduced the number of seedlings by about 50% compared to the NPWC check treatment (Figure 7). In 2007 the Fall Start Low Intensity System was less effective than the other systems designed to control perennial weeds. In 2008 and 2009, seedling dandelion numbers were quite similar across all six herbicide systems. This is most likely due to the fact that dandelion is a ubiquitous species that is a prolific producer of wind-dispersed seeds and so the recruitment rate for new seedlings is high regardless of the herbicide system employed. Due to the small size of the plots compared to farm fields and the close proximity of the NPWC check, dandelion seeds would have spread from one treatment to another. The herbicide systems employed for each crop included a short-term residual in-crop treatment (florasulam or imazamox/imazethapyr) either once or twice throughout the four year rotation. These treatments would be expected to control emerging seedlings for several weeks after application but they did not have any lasting impact on the recruitment of new seedlings in this study.

Contrasts for seedling dandelion numbers as determined post-harvest were not consistent. The contrast for the use of herbicides for perennial weed control vs the NPWC system was highly significant in 2007, non-significant in 2008 and significant in 2009. The contrast for treatment differences was non-significant in all three years as was the contrast for High vs Medium / Low Herbicide Intensity systems and Spring vs Fall based systems.

Figure 7. Effect of herbicide intensity on the numbers of seedling dandelion plants present after crop harvest averaged over wheat, canola, barley and field pea crops in a direct seeding system near Colonsay, SK, 2006-2009.



Summary:

Table 3 summarizes our assessment of the overall effectiveness of the six herbicide systems for control of seedling and established dandelions at three times during the season; just prior to seeding, just prior to in-crop herbicide application and after crop harvest. One system, Fall Only High Intensity, stands out as superior to the other four systems in terms of efficacy on both seedling and established plants throughout the growing season. The Spring Only High Intensity system also resulted in good overall control of dandelion although it was not as effective in terms of reducing the number of established dandelions present each spring. Table 3 also clearly shows that none of the systems prevented the recruitment of dandelion seedlings at the end of the season. These seedlings (or at least a high proportion of them) would be expected to survive the winter and become a factor to be dealt with the following spring.

Table 3. Summary of herbicide system effects on seedling and dandelion populations at three times during the growing season averaged over wheat, canola, barley and field pea crops in a direct seeding system near Colonsay, SK, 2006-2009.

Herbicide System	Pre-Seeding		In-Crop		Post-Harvest	
	<5 cm	>5 cm	<5 cm	>5 cm	<5cm	>5 cm
No Perennial Weed Control	■	■	■	■	■	■
Fall Only High Intensity					■	
Fall Start Low Intensity			■	■	■	■
Fall Start Medium Intensity					■	
Spring Only High Intensity					■	
Spring Start Medium Intensity	■	■			■	

Effective control
Mediocre control
■ Poor control

Examining a number of treatment contrasts for effects on established dandelions (Table 4) leads us to conclude that:

- All five herbicide systems designed for dandelion control were superior to the NPWC check throughout the growing season and throughout the course of the experiment.

- The treatments designed for dandelion control differed in their effectiveness most of the time.
- There were relatively few differences between systems that had an emphasis on fall treatment vs those that emphasized spring treatment. Our conclusion that "doing something" to control dandelions is more important than the timing of the application.
- High herbicide intensity systems were generally more effective than medium and low intensity systems.

Table 4. Summary of contrasts for established dandelions plants present at various sampling times averaged over wheat, canola, barley and field pea crops in a direct seeding system near Colonsay, SK, 2007-2009.

Contrast	2007	2008	2009
NPWC vs herbicide for perennial weed control			
Pre-seed			
In-crop			
Post-harvest			
Treatment differences			
Pre-seed			
In-crop	■		
Post-harvest			
Fall vs Spring based systems			
Pre-seed	■	■	■
In-crop	■		■
Post-harvest	■		■
High vs Medium / Low herbicide intensity			
Pre-seed			■
In-crop	■		
Post-harvest			
Highly Significant **Significant**	■	■	■

In general, there were fewer significant responses for seedling dandelions than there were for established plants (Table 5). The most consistent response was to the use of herbicides for perennial weed control vs the NPWC system. Among the treatments for perennial weeds, the response was significant slightly less than half the time. There was very little difference between Fall vs Spring based herbicide systems and likewise for High vs Medium / Low Intensity herbicide systems. The conclusion to be drawn is that a species such as dandelion will continuously reinvade an area in spite of effective control measures being applied.

Table 5. Summary of contrasts for seedling dandelion plants present at various sampling times averaged over wheat, canola, barley and field pea crops in a direct seeding system near Colonsay, SK, 2007-2009.

Contrast	2007	2008	2009
NPWC vs herbicide for perennial weed control			
Pre-seed			
In-crop			
Post-harvest			
Treatment differences			
Pre-seed			
In-crop			
Post-harvest			
Fall vs Spring based systems			
Pre-seed			
In-crop			
Post-harvest			
High vs Medium / Low herbicide intensity			
Pre-seed			
In-crop			
Post-harvest			

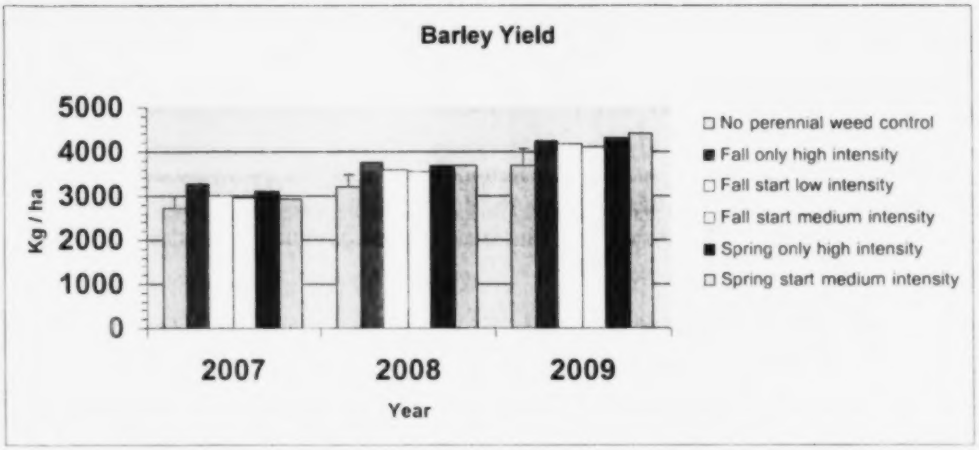
Highly Significant **Significant** **Not Significant**

Crop Yield.

Barley yields tended to increase over time, averaging approximately 3,000 kg/ha in 2007 and 4,000 kg/ha in 2009 (Figure 8). In 2007, only the Fall Only High Intensity and Spring Only High Intensity systems increased yield over the No Perennial Weed Control (NPWC) system but none of the five perennial weed control systems differed from each other in terms of crop yield. In 2008, all five of the systems designed to control dandelions resulted in yields that exceeded that of the NPWC check. As in 2007, the Fall Only High Intensity system resulted in the highest yield but this was not significantly different than the other perennial weed control systems. Overall yields were highest in 2009 and, again, all of the perennial weed control systems were superior to the NPWC check. However, the yield resulting from the Fall Start, Medium Intensity system was not statistically different than the NPWC check.

There were a number of significant contrasts for yield in barley. The contrast for the NPWC system vs herbicides was highly significant in all years and the contrast for high vs medium/low herbicide intensity was significant in 2007 but not in 2008 0r 2009. Contrasts for fall vs spring based herbicide systems and for treatment differences were not significant.

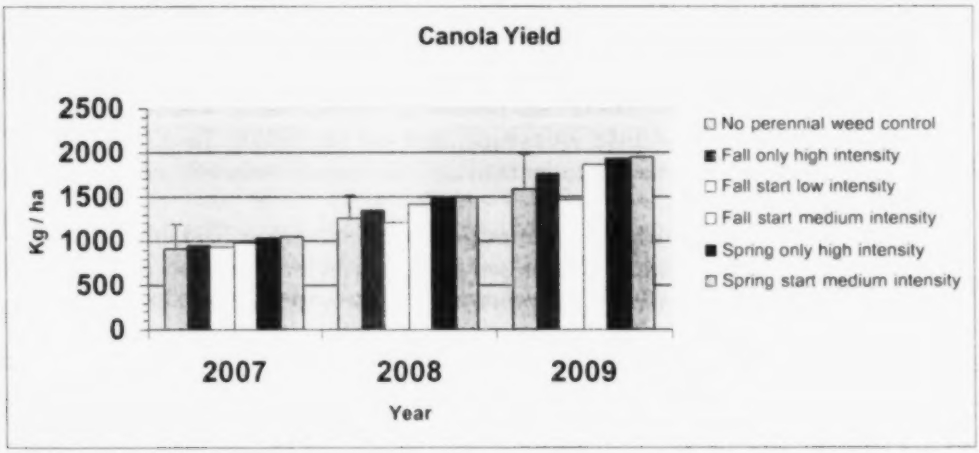
Figure 8. Effect of intensity of herbicide use for dandelion control on the yield of barley in a direct seeding system near Colonsay, SK, 2007-2009.



Canola yields also increased over time, averaging about 1,000 kg/ha in 2007 and approximately 1,750 kg/ha in 2009 (Figure 9). In 2007, 2008 and 2009, none of the perennial weed control systems increased canola yield above that of the NPWC check. However, both the Spring Only High Intensity and Spring Start Medium Intensity Systems consistently resulted in the highest yields and the Fall Start Low Intensity System resulted in the lowest yield when comparing the five systems designed to provide perennial weed control.

There were no significant contrasts for yield in canola.

Figure 9. Effect of intensity of herbicide use for dandelion control on the yield of canola in a direct seeding system near Colonsay, SK, 2007-2009.



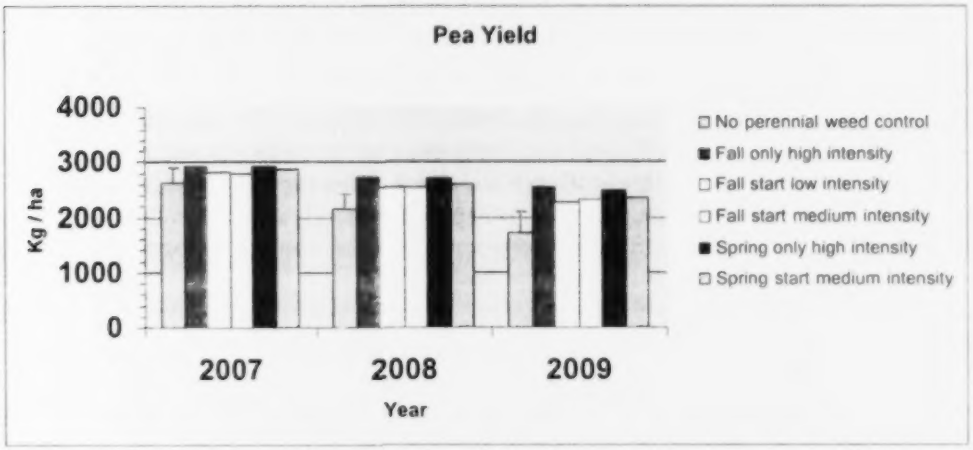
Pea.

In contrast to the other three crops, field pea yield declined over the course of the study (Figure 10). Yields were nearly 3,000 kg/ha in 2006 and about 2,200 kg/ha in 2009. The reason for this is not clear but we speculate the dry, cool springs experienced in 2008 and 2009 resulted in delayed and reduced crop establishment and the pea crops did not respond as readily to the

moisture received later in the growing seasons in those two years. In 2007, the Fall Only High Intensity and the Spring Only High Intensity systems resulted in greater yield than did the NPWC check. However, there were no differences in yield among the five systems designed to provide perennial weed control. In 2008, all five perennial weed control systems increased over the NPWC system but there were no differences among the five systems. The same results were observed in 2009.

There were some significant contrasts for yield in field pea. The NPWC vs herbicide contrast was highly significant in all years but the contrasts for fall vs spring based herbicide systems, high vs medium/low intensity herbicide systems and treatment differences were all non-significant.

Figure 10. Effect of intensity of herbicide use for dandelion control on the yield of pea in a direct seeding system near Colonsay, SK, 2007-2009.

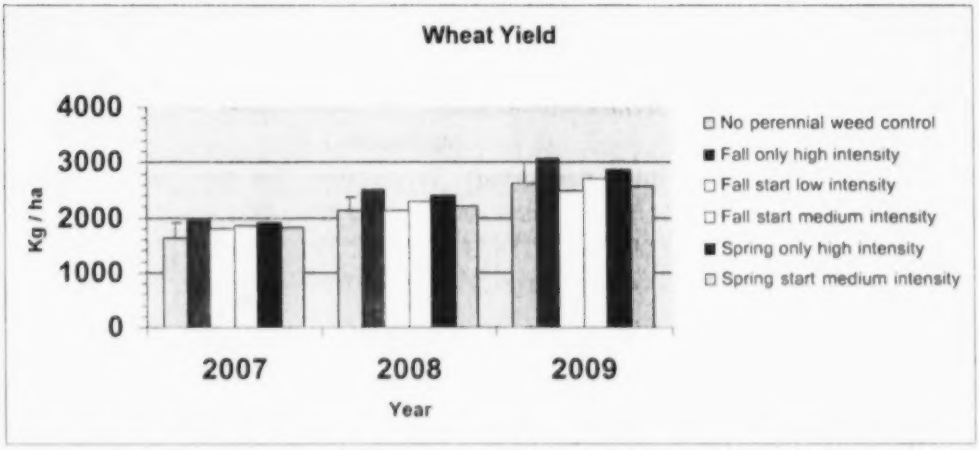


Wheat yield increased over time with yields averaging about 1,800 kg/ha in 2007 and about 2,500 kg/ha in 2009 (Figure 11). Throughout all three years, only the Fall Only High Intensity system resulted in wheat yield that was greater than that of the NPWC check. The other four perennial weed control systems did not differ from each other and the NPWC check. The Fall Only High Intensity system was consistently better than the other weed control systems.

The NPWC vs herbicide contrast for yield was significant in 2007 but not in 2008 or 2009. Contrasts for fall vs spring based herbicide systems and for treatment differences were both significant in 2008 and 2009 but not in 2007. The contrast for fall vs spring based herbicide systems was not significant.

When yields were averaged across all crops there were few differences among systems for perennial weed control (Figure 12). However, the Fall Only High Intensity system consistently out yielded the NPWC check. The other system that tended to perform better than the others was the Spring Only High Intensity system. Thus, we can say that the two systems that involved the highest levels of herbicide use intensity resulted in the highest crop yields on a fairly consistent basis. This result is consistent with the fact that these two herbicide systems also resulted in the best overall control of dandelions throughout the course of this study. Having said that, the Spring Start Medium Intensity system also performed quite well in canola and barley but it

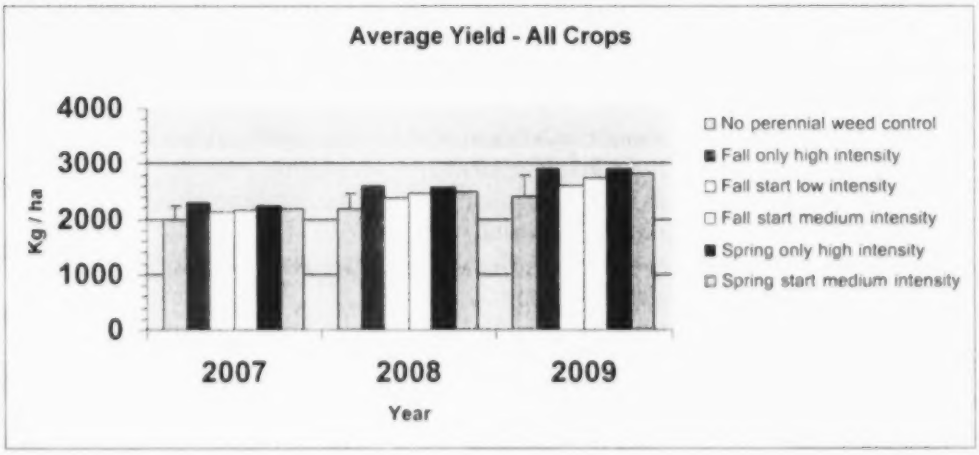
Figure 11. Effect of intensity of herbicide use for dandelion control on wheat yield in a direct seeding system near Colonsay, SK, 2007-2009.



tended to fall down in wheat and pea.

The contrast for the NPWC system vs herbicide contrast was highly significant in all years and the high vs medium/low intensity herbicide contrast was significant for all years as well. Treatment differences were highly significant in 2008 and 2009 but not in 2007. The contrast for fall vs spring based herbicide systems was not significant.

Figure 12. Effect of intensity of herbicide use for dandelion control on crop yield averaged over a wheat-canola-barley-pea rotation in a direct seeding system near Colonsay, SK, 2007-2009.



Economic Analysis.

Net returns (Gross value of crop produced minus the cost of herbicides and their application) are summarized in Table 6. All of the five herbicide systems designed to control dandelions resulted in higher net returns than the NPWC check but there were no significant differences among the five systems. However, in keeping with the results for dandelion control and for crop yield, the

Fall Only High Intensity and the Spring Only High Intensity systems tended to produce the greatest net returns.

Table 6. Total net returns from six herbicide systems for dandelion control in a wheat-canola-barley-pea rotation with four different starting points and averaged across all starting points in a direct seeding system near Colonsay, SK, 2006 – 2009.

Herbicide System	Net Return				
	Wheat Start	Canola Start	Barley Start	Pea Start	Average*
No perennial Weed Control	$751.06	$841.70	$831.48	$739.51	$790.94 b
Fall Only High Intensity	$877.42	$1,118.83	$989.29	$787.98	$943.38 a
Fall Start Low Intensity	$840.46	$1,009.22	$1,000.43	$858.84	$927.24 a
Fall Start Medium Intensity	$844.13	$1,144.42	$945.14	$795.60	$932.33a
Spring Only High Intensity	$924.80	$1,037.05	$954.93	$857.61	$943.60 a
Spring Start Medium Intensity	$884.51	$970.48	$879.29	$819.66	$888.48 a

* Means followed by the same letter do not differ based on LSD, p = 0.05.

(e) Conclusions and Recommendations

- The Fall Only High Intensity system appears to have been most effective for controlling established dandelion plants. In terms of overall weed control the Spring Only High Intensity program was also very effective. Although there were no significant differences in yield among the five systems designed to control dandelions, these two systems tended to result in the best yields and net economic returns. Thus we conclude that a relatively intensive herbicide program is required to maintain long-term control of an invasive species such as dandelion and maximize net returns.
- Intensive herbicide programs can provide equally good control of dandelion whether started in the fall or in the spring. The High Intensity programs were more effective than Medium and Low Intensity systems for reducing dandelion numbers, especially numbers of established plants.
- The Fall Start Low Intensity system which began with a heavy (900 g ai/ha) application of glyphosate and then reverted to a low intensity herbicide regime, provided initial control of established dandelions but it was not effective for controlling established dandelions over the four year course of the trial.
- It generally will require at least two consecutive years of effective control of to have a significant impact on a dandelion infestation.
- None of the herbicide systems were effective at preventing re-infestation of dandelion seedlings. Dandelion is a ubiquitous, wind dispersed species that can rapidly re-infest an area following effective control of the existing population.
- Established dandelions can reduce the yield of competitive crops, especially in years when spring moisture is limiting. In 2009, yield increases of 38%, 20%, 14% and 50% were recorded in wheat, canola, barley and pea, respectively.

Overall conclusion.
Rating the overall performance of the systems in terms of weed control, crop yield and net economic return, the two most intensive herbicide systems, Fall Only High Intensity and Spring Only High Intensity appear to be the best choices.

Herbicide System	Weed Control	Crop Yield	Net Returns
No Perennial Weed Control			
Fall Only High Intensity			
Fall Start Low Intensity			
Fall Start Medium Intensity			
Spring Only High Intensity			
Spring Start Medium Intensity			

Best control / yield / return

Lower but not significantly < Best

Poor control / yield / return

A similar trail was conducted by Mr. Bill May at the AAFC research farm at Indian Head, SK during the years 2005 -2008. It is our intention to combine the results of the two projects with an aim to present the results at the Canadian Weed Science Society and ultimately in a scientific anuscript.

(f) Acknowledgements

We are grateful to Mr. Allan Garner for allowing us to use his land to conduct this experiment and to Dr. F. C. Stevenson for assistance with statistical analysis and the preparation of Figures.

The financial support of the Saskatchewan Agriculture Development Fund is gratefully acknowledged. The results of this research will be formally presented at the annual conference of the Canadian Weed Science Society in Regina in November 2010 and will be ADF support will be recognized at that time.

We are extremely grateful our Research Technicians, Gerry Stuber, Teri Ife and Arlene Gravelle. This project could not have been accomplished without their tremendous dedication and attention to detail.

(g) Literature Cited

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(h) Appendicies

P values for contrasts for treatment effects on crop yield

effect	yld
crop	0.007
trt	0.913
crop*trt	0.592
time	0.230
time*crop	0.023
time*trt	0.131
time*crop*trt	0.388
cont vs. herb	0.000
cont vs. herb t=2	0.001
cont vs. herb t=3	0.000
cont vs. herb t=4	0.000
fall vs. sprg	0.382
fall vs. sprg t=2	0.717
fall vs. sprg t=3	0.202
fall vs. sprg t=4	0.112
high vs. med/low	0.011
high vs. med/low t=2	0.038
high vs. med/low t=3	0.007
high vs. med/low t=4	0.014
trt diffs	0.099
trt diffs t=2	0.306
trt diffs t=3	0.042
trt diffs t=4	0.042
cont vs. herb barley	0.000
fall vs. sprg barley	0.994
high vs. med/low barley	0.047
trt diffs barley	0.286
cont vs. herb barley t=2	0.003
cont vs. herb barley t=3	0.000
cont vs. herb barley t=4	0.001
fall vs. sprg barley t=2	0.467
fall vs. sprg barley t=3	0.468
fall vs. sprg barley t=4	0.154
high vs. med/low barley t=2	0.022
high vs. med/low barley t=3	0.175

high vs. med/low barley t=4	0.791
trt diffs barley t=2	0.126
trt diffs barley t=3	0.551
trt diffs barley t=4	0.613
cont vs. herb canola	0.276
fall vs. sprg canola	0.118
high vs. med/low canola	0.806
trt diffs canola	0.445
cont vs. herb canola t=2	0.513
cont vs. herb canola t=3	0.181
cont vs. herb canola t=4	0.182
fall vs. sprg canola t=2	0.335
fall vs. sprg canola t=3	0.059
fall vs. sprg canola t=4	0.062
high vs. med/low canola t=2	0.947
high vs. med/low canola t=3	0.606
high vs. med/low canola t=4	0.467
trt diffs canola t=2	0.886
trt diffs canola t=3	0.173
trt diffs canola t=4	0.116
cont vs. herb pea	0.000
fall vs. sprg pea	0.485
high vs. med/low pea	0.097
trt diffs pea	0.521
cont vs. herb pea t=2	0.022
cont vs. herb pea t=3	0.000
cont vs. herb pea t=4	0.000
fall vs. sprg pea t=2	0.493
fall vs. sprg pea t=3	0.550
fall vs. sprg pea t=4	0.731
high vs. med/low pea t=2	0.190
high vs. med/low pea t=3	0.084
high vs. med/low pea t=4	0.149
trt diffs pea t=2	0.713
trt diffs pea t=3	0.488
trt diffs pea t=4	0.665
cont vs. herb wheat	0.025
fall vs. sprg wheat	0.885
high vs. med/low wheat	0.022
trt diffs wheat	0.155
cont vs. herb wheat t=2	0.021
cont vs. herb wheat t=3	0.071
cont vs. herb wheat t=4	0.407
fall vs. sprg wheat t=2	0.948
fall vs. sprg wheat t=3	0.841
fall vs. sprg wheat t=4	0.825
high vs. med/low wheat t=2	0.174
high vs. med/low wheat t=3	0.005
high vs. med/low wheat t=4	0.005
trt diffs wheat t=2	0.662
trt diffs wheat t=3	0.042
trt diffs wheat t=4	0.040

P values for contrasts for effects on seedling dandelions (<5 cm diameter)

Max of ProbF	Year		
effect	2007	2008	2009
block	0.001	0.000	0.045
var	0.000	0.000	0.000
var*block	0.000	0.003	0.000
trt	0.000	0.000	0.000
block*trt	0.000	0.001	0.140
var*trt	0.051	0.000	0.038
var*block*trt	0.426	0.166	0.915
cont vs. herb preseed	0.000	0.000	0.001
cont vs. herb incrop	0.135	0.000	0.024
cont vs. herb postharv	0.000	0.390	0.031
trt diffs preseed	0.023	0.000	0.000
trt diffs incrop	0.271	0.003	0.337
trt diffs postharv	0.297	0.571	0.926
fall vs. sprg preseed	0.138	0.320	0.311
fall vs. sprg incrop	0.300	0.046	0.472
fall vs. sprg postharv	0.813	0.594	0.675
high vs. med/low preseed	0.009	0.027	0.283
high vs. med/low incrop	0.698	0.008	0.115
high vs. med/low postharv	0.310	0.121	0.657

P values for contrasts for treatment effects on established dandelions (>5 cm diameter)

Max of ProbF	Year		
effect	2007	2008	2009
block	0.002	0.008	0.001
var	0.000	0.000	0.000
var*block	0.446	0.091	0.734
trt	0.000	0.000	0.000
block*trt	0.000	0.000	0.000
var*trt	0.107	0.000	0.006
var*block*trt	0.931	0.998	0.977
cont vs. herb preseed	0.000	0.000	0.000
cont vs. herb incrop	0.000	0.000	0.000
cont vs. herb postharv	0.000	0.000	0.000
trt diffs preseed	0.000	0.000	0.000
trt diffs incrop	0.326	0.000	0.000
trt diffs postharv	0.013	0.001	0.000
fall vs. sprg preseed	0.072	0.861	0.414
fall vs. sprg incrop	0.350	0.009	0.113
fall vs. sprg postharv	0.485	0.014	0.092
high vs. med/low preseed	0.001	0.001	0.453
high vs. med/low incrop	0.052	0.000	0.002
high vs. med/low postharv	0.008	0.005	0.001

i) Other

Extension Presentations, K. Sapsford - March to November 2009

March 5	Scott Research update – Presentation - Perennial Broadleaf weed control Initiative – Dandelion control – 250 agronomist/farmers
Mar 17	Cargill Meeting – Presentation – New herbicides, Kochia control and dandelion control – 50 farmers
April 8	NuFarm meeting in St Brieux – Dandelion control – 25 farmers
Nov 18	AgriTrend meeting, Saskatoon - Dandelion and winter annual weed control

News & magazine articles

- Growing Knowledge – Fall 2009 newsletter – "Weed Science Corner: battling dandelions and winning".
- UFA – Post harvest weed control – Website article
- Top Crop Manager – Post harvest weed control
- In 2008, agronomists employed by Cargill visited the trial site in August. In addition, Clark Brenzil, Provincial Weed Control Specialist, visited the trial site on two occasions (2007 and 2008).

See also the attached Herbicide Research Update presented to SK Ministry of Agriculture and SIA sponsored agronomists update session in Saskatoon, December, 2008.

Personnel Involved in the Project:
2006

Name	Position	Funding Source
F.A. Holm	Project Manager	CDC Operating Budget (to June 30, 2006); U of SK Operating Budget (since July 1, 2006)
K. Sapsford	Research Assistant	CDC Royalty Account – to June 30, 2006; Weed Research Program – External funds – (since July 1, 2006)
G. Stuber	Research Technician	ADF Project 20030520
T. Ife	Research Technician	Weed Research Program – External funds
N. Gray	**Summer Student**	**ADF Project 20040401**
A. MacPherson	**Summer Student**	**ADF Project 20040401**
A. Sagin	Summer Student	Weed Research Program – External funds
E. Simington	Summer Student	Weed Research Program – External funds

2007

Name	Position	Funding Source
F.A. Holm	Project Manager	U of SK Operating Budget
K. Sapsford	Research Assistant	Weed Research Program – External funds
G. Stuber	Research Technician	ADF Project 20030520
T. Ife	Research Technician	Weed Research Program – External funds
N. Gray	**Summer Student**	**ADF Project 20040401**
Aaron Archer	Summer Student	Weed Research Program – External funds
A. Sagin	Summer Student	Weed Research Program – External funds
J. Krieger	Casual help - harvest	Weed Research Program – External funds

2008

Name	Position	Funding Source
F.A. Holm	Project Manager	U of SK Operating Budget
K. Sapsford	Research Assistant	Weed Research Program – External funds
G. Stuber	Research Technician	ADF Project 20030520
A. Gravelle	Research Technician	Weed Research Program – External funds
Alisha McLean	**Summer Student (4 months)**	**ADF Project 20040401**
Niclole Lynn	**Summer Student (1 month)**	**ADF Project 20040401**
Michelle Soron	Summer Student	Weed Research Program – External funds
Ashlyn Gavelin	Summer Student	Weed Research Program – External funds

2009

Name	Position	Funding Source
F.A. Holm	Project Manager	U of SK Operating Budget
K. Sapsford	Research Assistant	**ADF Project 20040401 (3 months) +** Weed Research Program – External funds
G. Stuber	Research Technician	ADF Project 20030520
A. Gravelle	Research Technician	**ADF Project 20040401 (2 months) +** Weed Research Program – External funds
K. Davis	**Summer Student (4 months)**	**ADF Project 20040401**
C. Little	**Summer Student (1 month)**	**ADF Project 20040401**
B. Johnson	Summer Student	Weed Research Program – External funds
S. Schiffer	Summer Student	Weed Research Program – External funds

No equipment was purchased with project funds.

Expense statement to be provided by Financial Services.